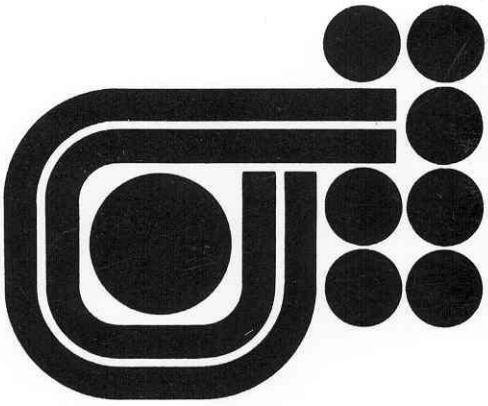
DEFIBRILLATOR ANALYZER
MODEL QED-III

OPERATOR'S MANUAL



BIO-TEK
INSTRUMENTS, INC.

BIO-TEK INSTRUMENTS

DEFIBRILLATOR ANALYZER
MODEL QED-III
OPERATOR'S MANUAL

MANUAL PART NUMBER 3330100

FOR

SERIAL NUMBERS 2218 AND UP

REVISION A

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INTRODUCTION TO QED-III OPERATOR'S MANUAL

This document is the operator's manual for the Bio-Tek Defibrillator Analyzer Model QED-III. It contains general information about the QED-III, a description of its components, and instructions for its use. **If a problem develops, the user should contact Bio-Tek at: 1-800-451-5172.** The user should never attempt to service the unit before consulting with Bio-Tek service personnel.

The objectives of this manual are to provide:

1. sufficient information about the design of the QED-III to enable the user to understand its use (Sections 1 and 2);

2. detailed guidance for maintaining, storing, and shipping the unit (Section 3);

3. procedures for setting up the QED-III (Section 4), for operating the unit (Section 5), for calibrating the unit (Section 6), and for troubleshooting (Section 7); and

4. a parts list (Section 8).

After becoming familiar with both the QED-III and this manual, please take the time to answer the questionnaire at the back of the manual. We want your feedback to help us to continually improve our products and our documentation.

1 QED-III GENERAL INFORMATION

1.1 Summary of features

Bio-Tek has designed the QED-III, a quantitative energy measuring system, to test AC and DC defibrillators for their energy output during operation. The QED-III is portable, lightweight, and battery operated and can be used wherever the energy output of a defibrillator needs to be evaluated. The instrument is easy to operate; test data can be quickly and accurately read from the QED-III meter.

1.2 Applications

The QED-III is designed to test defibrillators that have grounded or ungrounded paddles. The test data supplied by the QED-III help medical personnel ensure that the energy output required during basic life support is actually produced. The QED-III also enables medical personnel to observe the waveform of the energy produced by a defibrillator. The waveform is displayed on an oscilloscope that is plugged into jacks provided on the QED-III.

Since the QED-III is portable it can be used in operating rooms, intensive care units, coronary care units, and rescue vehicles. Defibrillators are used during emergency critical care and must always function properly; the energy measurement data provided by the QED-III help ensure that the defibrillators produce the desired energy.

2 QED-III DESCRIPTION

2.1 QED-III specifications

The QED-III is designed for use with AC and DC defibrillators and sums the positive and negative output energies.

Meter Readings	Displayed in watt-seconds (joules)
Display Capability (Size of Scale)	4 1/2 inches (11.4 cm)
Input Impedance	50 ohms +/- 1%
Accuracy	+/- 2% of full scale for all waveforms, including trapezoidal waveforms to 50 milliseconds in duration and high-voltage pulses to 7000 V in amplitude
Ranges	0 — 50 watt-seconds (1 watt-second increments) 0 — 500 watt-seconds (10 watt-seconds increments) 0 — 1000 watt-seconds (20 watt-seconds increments)
Reading Duration	Controlled by depression of the lefthand contact plate
Power	Four 9 V alkaline transistor batteries (Duracell[R] MN1604 or equivalent)
Battery Life	Greater than one year
Waveform Display Capability	2 female banana jacks for oscilloscope. Attenuation is 1:10,000 of input waveform. Isolated through an opto-isolator.
Dimensions	5" H x 14-3/4" W x 8-3/4" D (12.7 cm x 36.2 cm x 22.2 cm)
Weight	8.7 pounds (3.9 kg)

[R] Duracell is a registered trademark of Duracell U. S. A.

2.2 QED-III description

The QED-III is housed in a heavy-duty formica case. The cover of the unit rests on a rubberized seal when the unit is closed, forming a barrier to dust and other foreign particles. The cover of the QED-III can be removed completely by positioning the unit so that the meter faces the user, unlatching the locks and then pushing the cover to the right. The QED-III is carried by a sturdy handle bolted into the front of the case. The QED-III can be placed upright or flat when in operation; rubber feet protect both the supporting surface and the QED-III.

The meter face of the QED-III is divided into three scales as illustrated in Figure 2.2-1. The scales are as follows:

Scale Range	Resolution
0 — 50 watt-seconds	1 watt-second
0 — 500 watt-seconds	10 watt-seconds
0 — 1000 watt-seconds	20 watt-seconds

Note that the lefthand scale reads both the 0-to-50 and the 0-to-500 ranges; when reading the lower range, disregard the final zero on this dual scale.

A battery check line (red) is located at mid-scale on the meter. The adjustment screw for the meter needle is also located at mid-scale, to the right of the meter window. The female banana jacks are used for the isolated output when the QED-III tests the waveform of the energy produced by a defibrillator. The black jack is for the ground lead from the oscilloscope; the red jack is for the probe.

The activation switch for the QED-III is located underneath the lefthand contact plate. The unit is "ON" when this plate is depressed because this switch powers the electronic circuitry of the QED-III.

The QED-III simulates the transthoracic resistance (TTR) of the human body and measures the output from a defibrillator subjected to this resistance.

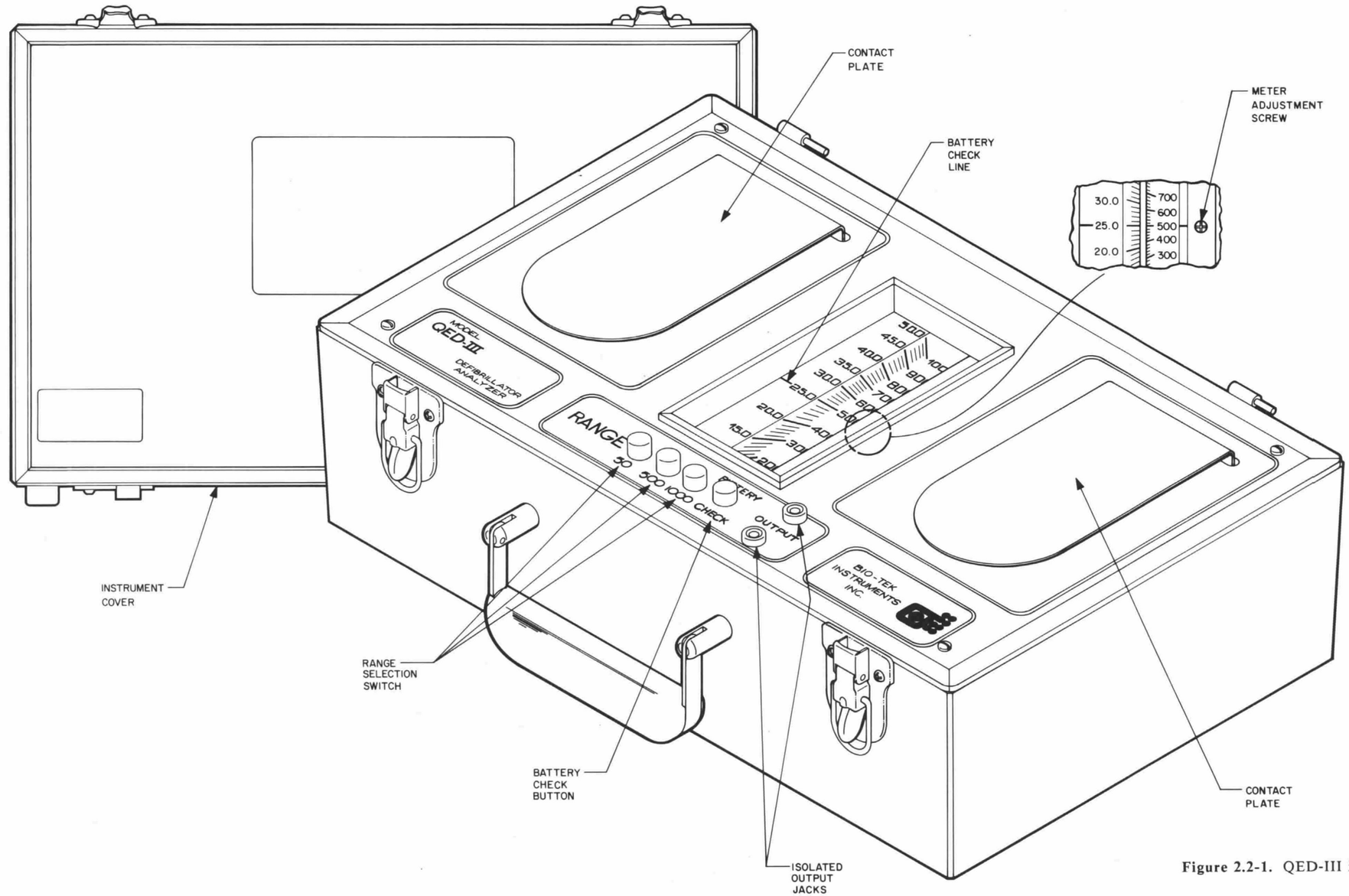


Figure 2.2-1. QED-III isometric view

3 SAFETY, MAINTENANCE, STORAGE, SHIPPING, AND WARRANTY

3.1 Electrical safety

An electrical safety inspection, including leakage tests, should be performed monthly on the defibrillator. The details of these tests are found in the following Electrical Safety Analyzer manuals available from Bio-Tek Instruments, Inc.:

Electrical Safety Analyzer Model 370, Operator's Manual

Digital Safety Analyzer Model 170, Operator's Manual

Digital Safety Analyzer Model 501, Operator's Manual.

In addition to leakage tests, the following safety precautions **must** be followed to ensure the safety of the operator when using a defibrillator:

1. Inspect the defibrillator daily. Examine the paddles, lead wires, and power cord for cracks and frays.
2. If the defibrillator is line powered, be sure that it is plugged into a grounded receptacle.
3. **Do not touch the paddles on the defibrillator.**
4. Grip one paddle in each hand. Apply the paddles firmly (approximating 25 pounds of pressure) to the QED-III plates. **Keep the paddles firmly depressed on the plates to prevent arcing that can cause injury to the operator and can damage the QED-III or the defibrillator.**
5. **Do not touch the contact plates on the QED-III when the defibrillator paddles are being pressed onto the plates.**
6. **Do not use any electrical paste or pads when testing a defibrillator with the QED-III.**
7. When replacing the batteries of the QED-III (as described in Section 3.2.2), all circuits are exposed. **Do not touch any part of the QED-III with the defibrillator paddles.**

3.2 Maintenance

3.2.1 Cleaning

The QED-III must be kept clean and moisture-free at all times. The unit can be cleaned effectively as follows:

CIRCUIT BOARD

1. After soldering, use an acid brush dipped in isopropyl alcohol to remove flux and dirt residue. Wipe dry with a paper towel. **Caution: Use the isopropyl alcohol in a well-ventilated area. Do not smoke or use near heat or flame.**

2. Repeat if necessary.

PANEL

1. Use compressed air, 30 psi maximum, to blow dust off of the panel.

2. Use all-purpose spray cleaner (409[R] or equivalent) on the electrode plates, meter and overlay. **Caution: Do not use solvents that damage plastic.**

CASE

1. Clean the outside formica surface with the all-purpose spray cleaner. Wipe dry with a paper towel.

2. Use compressed air to blow dust out of the inside of the case. **Caution: The inside of the case must be moisture-free to prevent corrosion of the electrical components.**

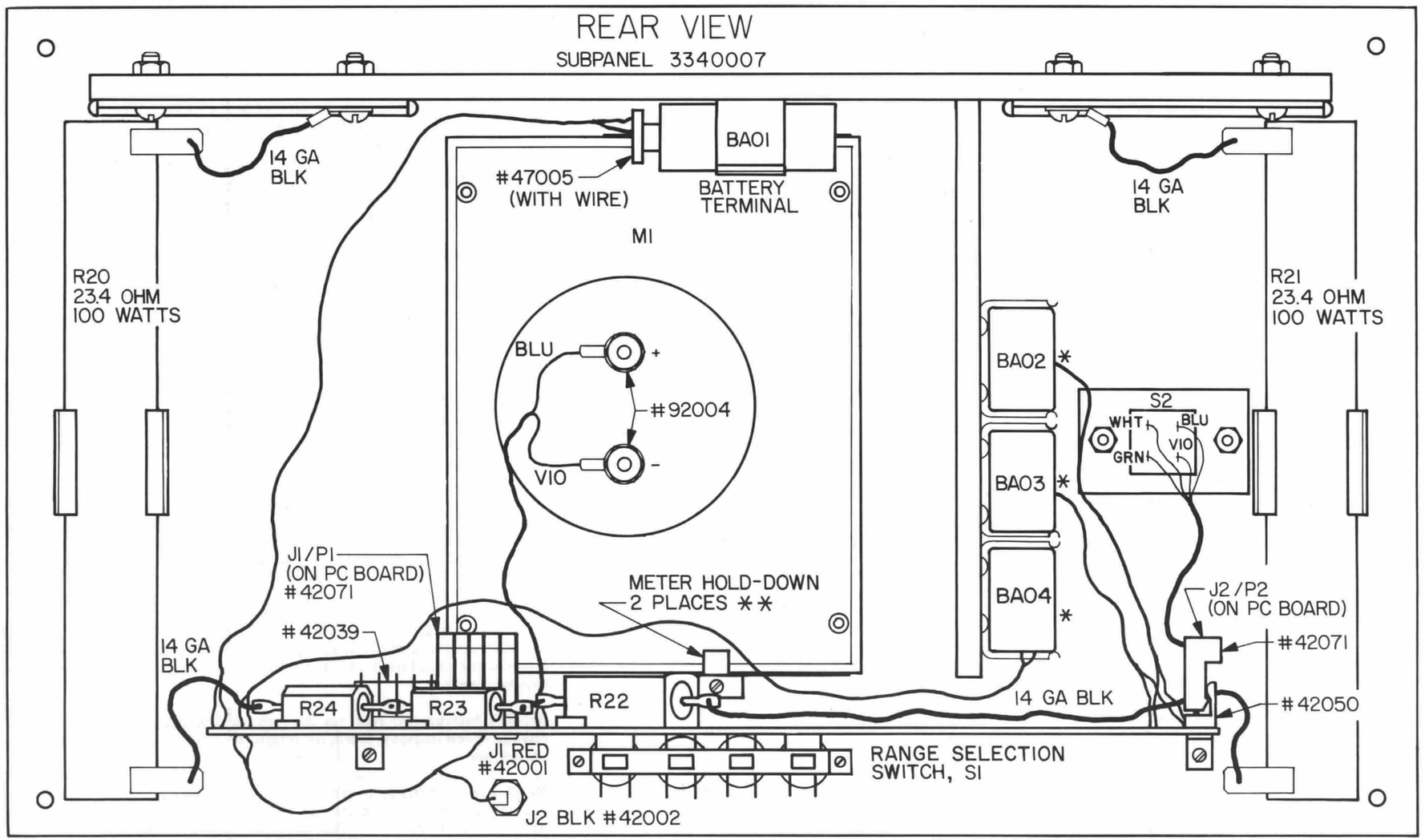
3.2.2 Battery replacement

When the QED-III meter indicates a reading below the red battery check line during the battery test (Section 4.3), all four 9 V batteries must be replaced. **Before replacing the batteries, reread Section 3.1: Electrical safety.**

1. Remove the four corner screws in the QED-III panel.

2. Lift the panel out of the case and turn to expose the batteries. (Refer to Figure 3.2.2-1 for location of the batteries.)

[R] 409 is a registered trademark of the Clorox Company.



COLOR KEY: BLK = BLACK RED = RED
BLU = BLUE VIO = VIOLET
GRN = GREEN WHT = WHITE

KEY: * BATTERY TERMINAL (SAME AS #47005 WITH WIRE)
** HOLD-DOWN COMES WITH BEZEL #92008
# PART NUMBER

Figure 3.2.2-1. QED-III component layout (rear view)

3. Remove the battery clips from the batteries and remove the batteries from their holders.

4. Replace the batteries with Duracell MN1604 batteries or the equivalent.

5. Test the two new batteries for the meter by pressing the red battery check button on the meter face. The meter must read above the red check line.

6. Test the two new batteries that are used in the opto-isolator circuit by depressing the activation switch (the lefthand contact plate). Check that the terminal voltage across BA03 and BA04 is greater than 7.5 V. (Refer to Figure 3.2.2-1 for the location of BA03 and BA04.)

7. Place the QED-III panel back into the case.

8. Tighten the four corner screws.

3.3 Storage and shipping

The QED-III should be stored at 77° F (25° C) with a relative humidity of 50%. The cover on the QED-III should always be closed and the latches snapped during storage and shipping. The storage environment should be free of vibration.

3.4 Warranty

Bio-Tek warrants the QED-III to the original purchaser for a period of one year from the original purchase date. The warranty is for normal use and service, against defective materials or workmanship. If the customer ships the QED-III defibrillator analyzer to Bio-Tek, postage pre-paid, and Bio-Tek determines the defect to be in materials or manufacturing, Bio-Tek shall either repair or replace the unit at Bio-Tek's option, without cost to the customer.

This warranty is void if the QED-III has been visibly damaged by accident, misuse, or has been repaired or altered by persons or stations not authorized by Bio-Tek, or which has had the serial number altered, defaced, or removed. Batteries are not covered by this warranty.

Bio-Tek Instruments reserves the right to discontinue the QED-III at any time and to change specifications, price, or design, without notice and without incurring any obligation.

Bio-Tek will continue to stock service parts for up to 5 years after the manufacture of the unit has been discontinued. Parts shall include all materials, charts, instructions, diagrams, and accessories that are furnished with the unit.

The purchaser agrees to assume all liability for any damages or bodily injury which may result from the use or misuse of the unit by the purchaser, his employees, agents, or customers.

4 INSTALLATION

4.1 Operating precautions

Refer to Section 3.1: Electrical safety, for precautions that **must** be followed to ensure the safety of the QED-III operator.

4.2 Unpacking and inspection

Inspect the QED-III for cracks or scratches on either the panel and the case. Check the meter needle to ensure that it is intact. Carefully inspect the handle to ensure that it is firmly attached to the case.

If any damage is found, immediately call Bio-Tek Instruments at: 1-800-451-5172.

4.3 Preparation for use

Find a relatively level surface on which to place the QED-III. Unlatch the locks on the unit and place it facing the operator so that the meter scale can be easily read.

5 OPERATION

5.1 General

The QED-III measures the energy delivered by a defibrillator by simulating the human body's resistance to current flow and then measuring the flow of energy through that resistance. The resistance of the human thorax (i.e., the TTR) under high voltage pulse conditions has been measured and found to be between 40 and 120 ohms. The standard resistance chosen in the measurement of the output energy of defibrillators is 50 ohms. The QED-III has an internal resistance of 50 ohms, thus simulating the resistance of the human body.

The QED-III is a precision analog instrument that computes the time integral of the power output from a defibrillator discharge. Energy is the product of current and voltage summed over the time during which the current and voltage are applied. Mathematically, energy is expressed as:

$$W = \int_0^t E(t)\, I(t)\, dt$$

where:

W = energy
E(t) = voltage as a function of time
I(t) = current as a function of time.

Ohm's Law can be expressed by the following equation:

$$E(t) = I(t)\, R$$

where:

I(t) = current as a function of time
R = resistance in ohms.

The preceding two equations can be combined to give the following energy relationship:

$$W = \int_0^t R\, I^2(t)\, dt$$

where:

R = 50 ohms.

The QED-III performs an energy measurement by attenuating the input current; the QED-III uses less than 1/1000 of the current supplied by the defibrillator. The QED-III squares the input current using a current squaring network and sums the current value (i.e., mathematically integrates) using a precision integrated circuit while at the same time multiplying by the constant R; this provides the exact energy of the applied pulse. Figure 5.1-1 shows what happens electrically to the output from a defibrillator when it is passed through the QED-III.

5.2 Battery check

It is recommended that the following battery check be performed before each test series whenever there is a time lag between testing.

1. Push the red battery check button located below the QED-III meter (see Figure 2.2.1).

2. Observe the meter reading. If the meter reads above the red line, the batteries used for energy measurements are satisfactory.

3. If the meter reads below the red line, refer to Section 3.2.2: Battery replacement.

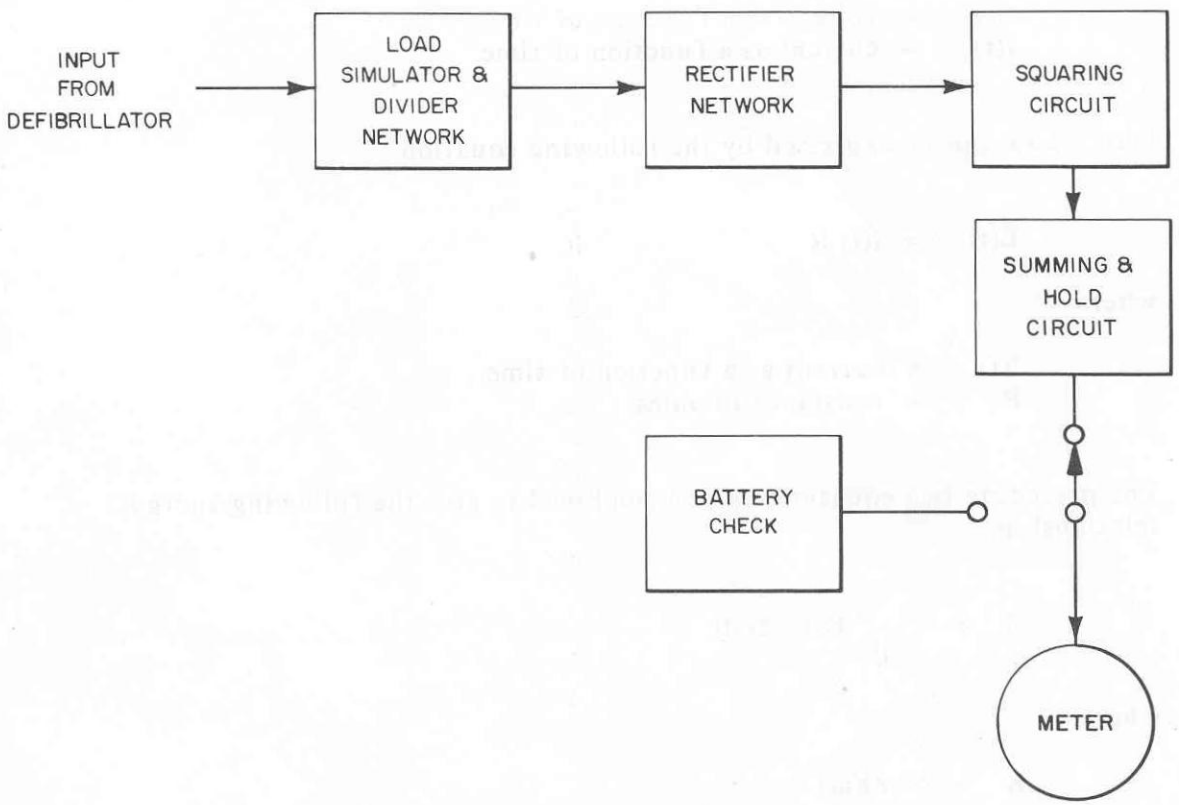


Figure 5.1-1. Block diagram

It may be necessary to check the isolation circuit batteries if no display appears on the oscilloscope after all connections are made. These batteries are checked as follows:

1. Remove the QED-III panel from its case. Be sure to observe all safety precautions detailed in Section 3.1: Electrical safety. **Do not discharge the defibrillator into the QED-III while it is out of its case.**

2. Depress the lefthand contact plate on the QED-III.

3. Measure the voltage across the terminals of BA03 and BA04 while continuing to depress the contact plate. (For location of these terminals, see Figure 5.2-1.)

4. Check the voltage reading; a minimum of 7.5 VDC is required.

5.3 Test procedure

5.3.1 Testing defibrillator energy output

The following procedure must be followed when testing the energy output of a defibrillator with the QED-III analyzer:

1. Turn the defibrillator on (follow manufacturer's instructions). Select the desired output energy.

2. Before conducting the test, push the red battery check button on the QED-III. (Refer to Section 5.2 for details of the battery check.)

3. To select the desired energy output range, depress the appropriate gray button on the range selection switch. If the anticipated output energy is unknown, select the 0-to-1000 watt-seconds range. If the range setting is too low, the meter will peg and bend the needle when excessive current is applied.

4. Simultaneously press one of the defibrillator paddles on the right contact plate of the QED-III and the other paddle on the left contact plate. (Use approximately 25 pounds of pressure on the contact plates to ensure good contact.)

5. Initiate a discharge from the defibrillator.

6. Observe the meter reading given in watt-seconds (joules) on the range selected. The meter will retain the reading as long as the left plate is depressed with the defibrillator paddle. (When observing the meter reading within the 0-to-500 watt-seconds range, ignore the decimal point used on the 0-to-50 watt-seconds range.)

5.3.2 Defibrillator output measurements and recordkeeping

The QED-III is designed to quickly and accurately calibrate the energy output from a defibrillator. Figure 5.3.2-1a shows the recommended format for recording energy output measurements for the QED-III.

A defibrillator can be calibrated by two methods using the QED-III; the method of calibration is dependent on what output information is required. Both Methods I and II are used to calibrate the defibrillator to determine energy output; Method I is the faster method. Method II provides additional information: an exact defibrillator meter setting is correlated with each energy output desired.

DEFIBRILLATOR OUTPUT MEASURMENTS METHOD I

1. Set the defibrillator meter to a benchmark value such as 50, 100, 150, or 200.
2. Record the meter setting under "defibrillator setting" on the chart (see Figure 5.3.2-1b).
3. Discharge the defibrillator into the QED-III.
4. Record the QED-III meter reading beside the defibrillator meter reading under "actual output" (see Figure 5.3.2-1b).
5. Set the defibrillator on another benchmark value; repeat Steps 2 through 4.

DEFIBRILLATOR OUTPUT MEASUREMENTS METHOD II

1. Set the defibrillator meter at 50 watt-seconds.
2. Discharge the defibrillator into the QED-III.
3. Observe the meter reading on the QED-III. If the QED-III does not read 50 watt-seconds, adjust the defibrillator either up or down to obtain an actual output of 50 watt-seconds.
4. When the defibrillator meter reading is found that gives 50 watt-seconds of output, record the values as shown in Figure 5.3.2-1c.
5. Repeat Steps 1 through 4 for values of 100, 200, 300, and 400 watt-seconds and any other energy output values that are important during operation.

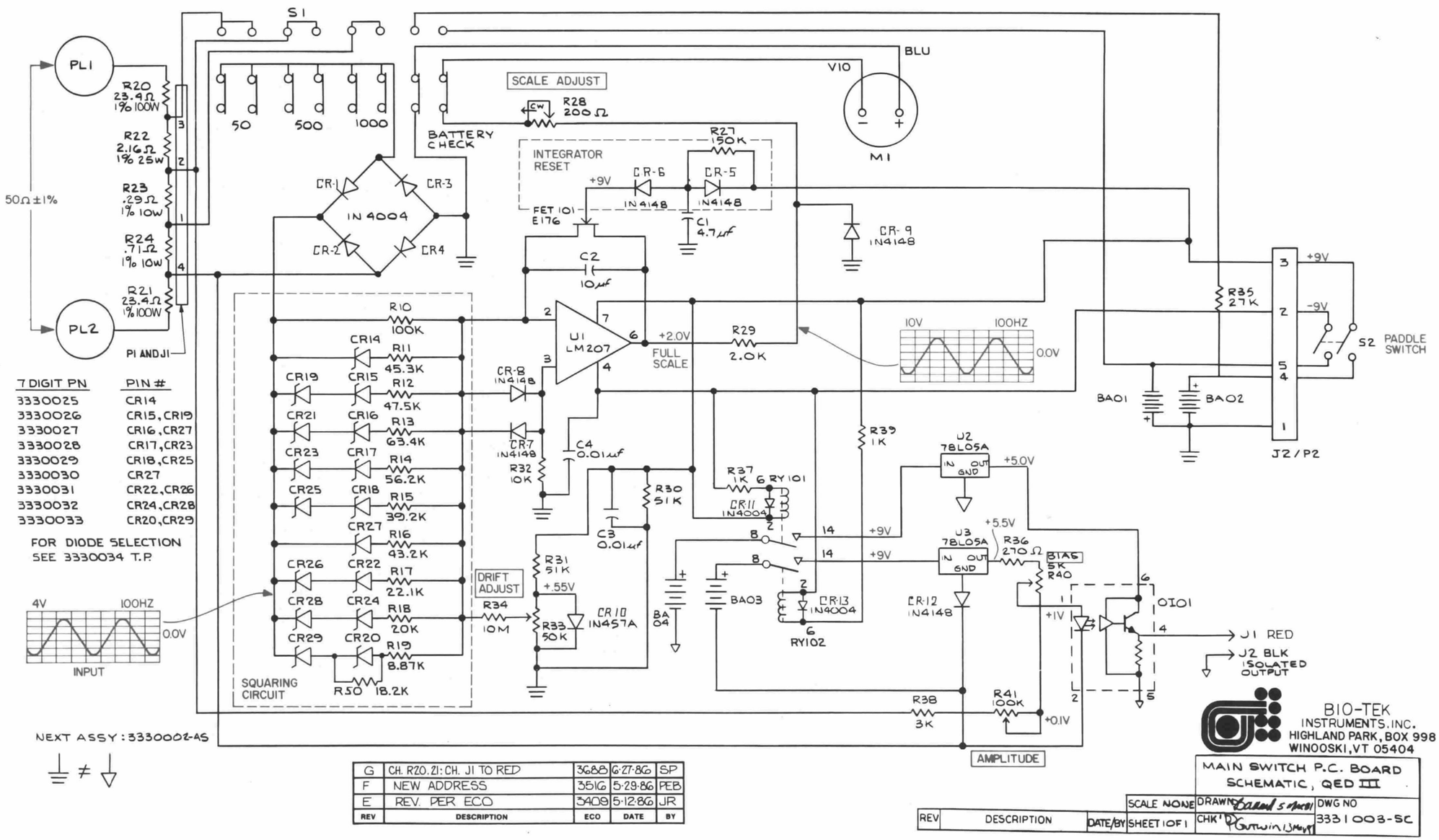
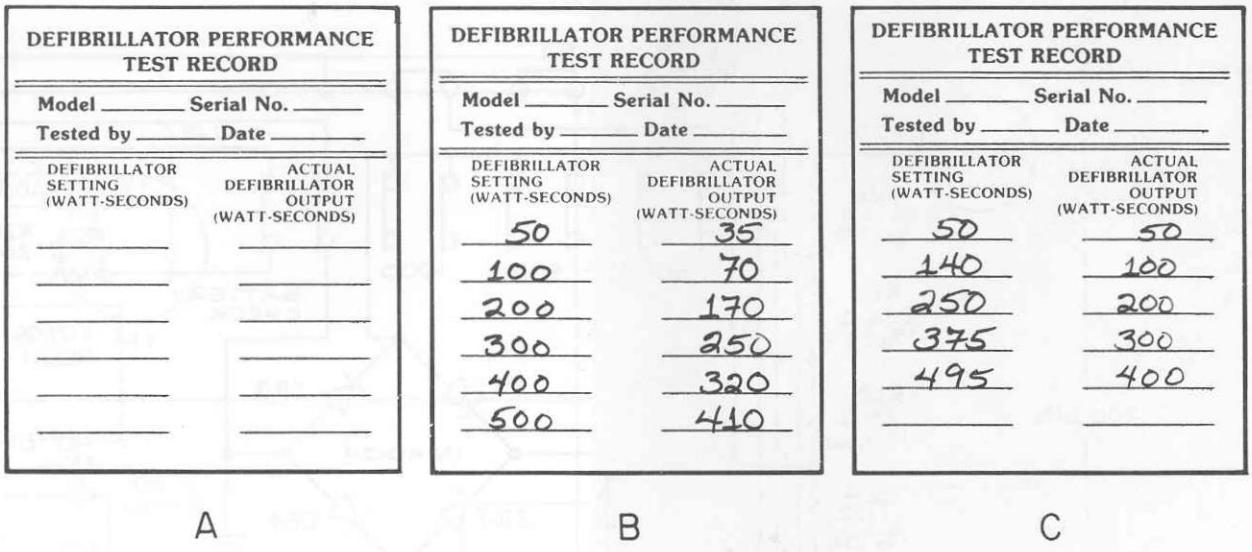


Figure 5.2-1. Main switch PC board schematic



DEFIBRILLATOR PERFORMANCE TEST RECORD

Model _____ Serial No. _____

Tested by _____ Date _____

DEFIBRILLATOR SETTING (WATT-SECONDS)	ACTUAL DEFIBRILLATOR OUTPUT (WATT-SECONDS)

A

DEFIBRILLATOR PERFORMANCE TEST RECORD

Model _____ Serial No. _____

Tested by _____ Date _____

DEFIBRILLATOR SETTING (WATT-SECONDS)	ACTUAL DEFIBRILLATOR OUTPUT (WATT-SECONDS)
50	35
100	70
200	170
300	250
400	320
500	410

B

DEFIBRILLATOR PERFORMANCE TEST RECORD

Model _____ Serial No. _____

Tested by _____ Date _____

DEFIBRILLATOR SETTING (WATT-SECONDS)	ACTUAL DEFIBRILLATOR OUTPUT (WATT-SECONDS)
50	50
140	100
250	200
375	300
495	400

C

Figure 5.3.2-1. Recommended recordkeeping

5.4 Instructions for use with an oscilloscope

5.4.1 Equipment setup

The QED-III provides isolated output jacks for displaying discharge waveforms on an oscilloscope. The output circuitry isolayes the discharge pulse and eliminates the danger of shorting the defibrillator output to ground through the oscilloscope. The operator should perform the following procedure using a storage oscilloscope:

1. Connect the oscilloscope to the QED-III using banana plug leads. Plug the oscilloscope ground lead into the black jack and the probe lead into the red jack. **Use only banana jack plugs to avoid damaging the QED-III.**

2. Set the oscilloscope trigger on external. Connect a lead between the input of the oscilloscope and the external input, or internally trigger the waveform to be displayed.

3. Set the time scale to 1 millisecond/division, then adjust to the desired expansion after observing the waveform output.

4. Set the gain to 0.2 V/division. Adjust the gain to the desired level after observing the waveform.

5. Activate storage control.

6. For most applications, set the oscilloscope input-coupling control to the AC mode.

Note

The QED-III isolated oscilloscope output has a quiescent DC level of 1-to-4 VDC when the lefthand paddle is depressed. The discharge waveform is superimposed on this DC level with a 10,000:1 attenuation factor. (For example, a +/- 5,000 V discharge results in a 0.5 V change in the signal level.) Placing the oscilloscope in the AC-coupled mode will block the nominal output level and enable the user to select a higher gain setting for the display of the discharge waveform.

5.4.2 Testing

If the defibrillator device under test is one which uses a discharge waveform with sizable DC components (i.e., trapezoidal or pulsitile discharge), better output waveform fidelity can be obtained by placing the oscilloscope in the DC coupling mode. The user can then view the discharge waveform with a gain setting of 1.0 V/division or can select a higher gain and use the oscilloscope vertical position control to help center the DC output level of the QED-III.

1. Discharge the defibrillator into the QED-III. The waveform is 1/10,000 of the input voltage through 50 ohms. The actual magnitude of the discharge voltage can be obtained by using the following equation:

$$V_{discharge} = V_{scope} - 10{,}000\ V_x$$

where:

V_x = 0 for AC input coupling

V_x = V_{BIAS} DC input coupling

V_{BIAS} = quiescent VDC present on the output

V_{scope} = oscilloscope input coupling.

2. Observe the waveform as it appears on the oscilloscope. Repeatedly discharge the defibrillator while adjusting the time and gain to the optimal scale for observation of the waveform.

3. If the waveform does not appear on the oscilloscope, reverse the placement of the defibrillator paddles on the QED-III contact plates. Repeat the discharge.

4. If the waveform still does not appear, readjust the trigger levels on the oscilloscope and repeat the preceding steps.

6 CALIBRATION

6.1 Calibration equipment list

The equipment needed to calibrate the QED-III is as follows:

1. Digital multimeter to read up to 100 VAC or VDC to within +/- 0.1 V and 50 ohms +/- 0.1%.
2. High voltage monopulse generator to produce a positive or negative pulse waveform of 1-to-50 milliseconds, with 1-to-100 V amplitudes at 15 milliamps.
3. AC voltage source continuously variable up to 100 V_{rms} at 20 milliamps.
4. Oscilloscope.
5. Meter to read V_{rms}.

6.2 Calibration

6.2.1 Energy measurements

The procedure for calibrating the energy measurements made by the QED-III is as follows:

1. Remove the four corner screws from the panel of the QED-III.
2. Lift the panel from its case.
3. Mechanically zero the meter by turning the screw next to the meter window (see Figure 2.2-1). **Do not depress the lefthand contact plate.**
4. Measure the resistance across the two contact plates and record the reading.
5. Depress the lefthand contact plate and observe the meter needle. If the needle drifts noticeably, adjust R33 on the main printed circuit board (see Figure 6.2.1-1 for location of R33). Continue to adjust the screw until the needle stops moving.
6. Release and then depress the contact plate to ensure that the meter needle no longer drifts.

7. Connect the output of the monopulse generator to the input of the high voltage amplifier. Connect the output of the high voltage amplifier to the diode between CR1 and CR4 (see Figure 6.2.1-1).

8. Apply input pulses that vary in amplitude from 0-to-100 V and that vary in time from 1-to-50 milliseconds. The energy is calculated from the following equation:

$$\text{Equivalent energy} = \frac{(R \times V)^2 T}{R}$$

where:

R = resistance in ohms measured in preceding Step 4
V = pulse voltage
T = pulse duration.

Remember: **The lefthand contact plate must be depressed to turn the QEDIII on and released to reset the QED-III.**

9. Adjust R28 (see Figure 6.2.1-1) until the QED-III meter needle reads accurately. **If the accuracy of the QED-III is not within +/- 2% of full scale, then the QED-III must be returned to the Bio-Tek Service Department for calibration.**

6.2.2 Opto-isolated scope output

The following calibration procedures must be performed carefully. **Failure to do so may result in damage to the QED-III.**

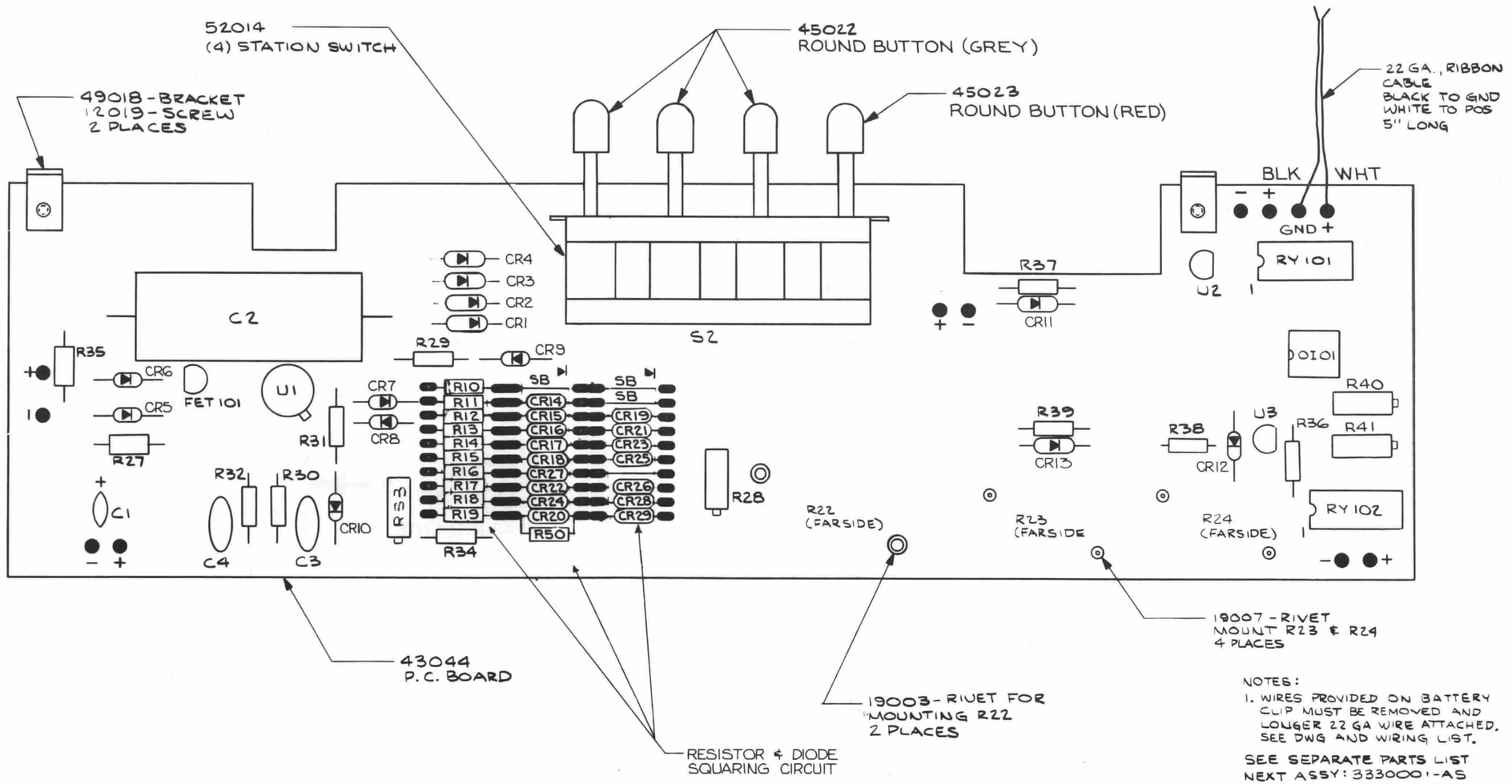
EQUIPMENT SETUP

1. Remove the connectors on the 10-pin header (P1/J1) on the main printed circuit board (see Figure 3.2.2-1 for location of the header). See Figure 6.2.2-1 for isolated output calibration equipment setup.

2. Connect an oscilloscope and an rms meter between the isolated output jacks, J1 and J2 (see Figure 3.2.2-1 for location of the jacks).

3. Connect the 0-to-100 VAC source between the second and fourth pin of the 10-pin header (P1/J1). **Do not turn on.** Be sure to count the pins from the end nearest the push buttons of the selection switch. (Disregard the numbers on the top of the PC board.)

4. Connect a digital voltmeter to monitor the output of the variable AC source.



NOTES:
1. WIRES PROVIDED ON BATTERY CLIP MUST BE REMOVED AND LONGER 22 GA WIRE ATTACHED. SEE DWG AND WIRING LIST.

SEE SEPARATE PARTS LIST
NEXT ASSY: 3330001-AS
SCHEMATIC: 3330003-SC

REV	DESCRIPTION	DATE/BY
I	Delete PCB number ECO 3688	6/27/86
H	REVISE PER ECO 3516	5/29/86
G	CHANGE 45022 TO ROUND BUTTON	5/16/86
F	CHANGE 4 STATION SWITCH ECO PIN FROM 43014 TO 52014 1313	7/10/84
E	ADD SQUARING CIR. ECO 819	7/19/83
D	REV PER ECO 000454	9/28/82
C	REV PER ECO 000286	2/ /82
B	RELEASE TO PRODUCTION PER ECO 000187	2/11/82
A	REV PER ECO 000165	12/29/81

SCALE: 2/1
SHEET 1 OF 2

BIO-TEK INSTRUMENTS, INC.
HIGHLAND PARK, BOX 998
WINOOSKI, VT. 05404-0998

MAIN SWITCH PC. BD ASSY - QED III
(COMPONENT LAYOUT)
TOP SIDE

DRAWN
CHK'D
DWG NO 3330002-AS

Figure 6.2.2-1. Main printed PC board

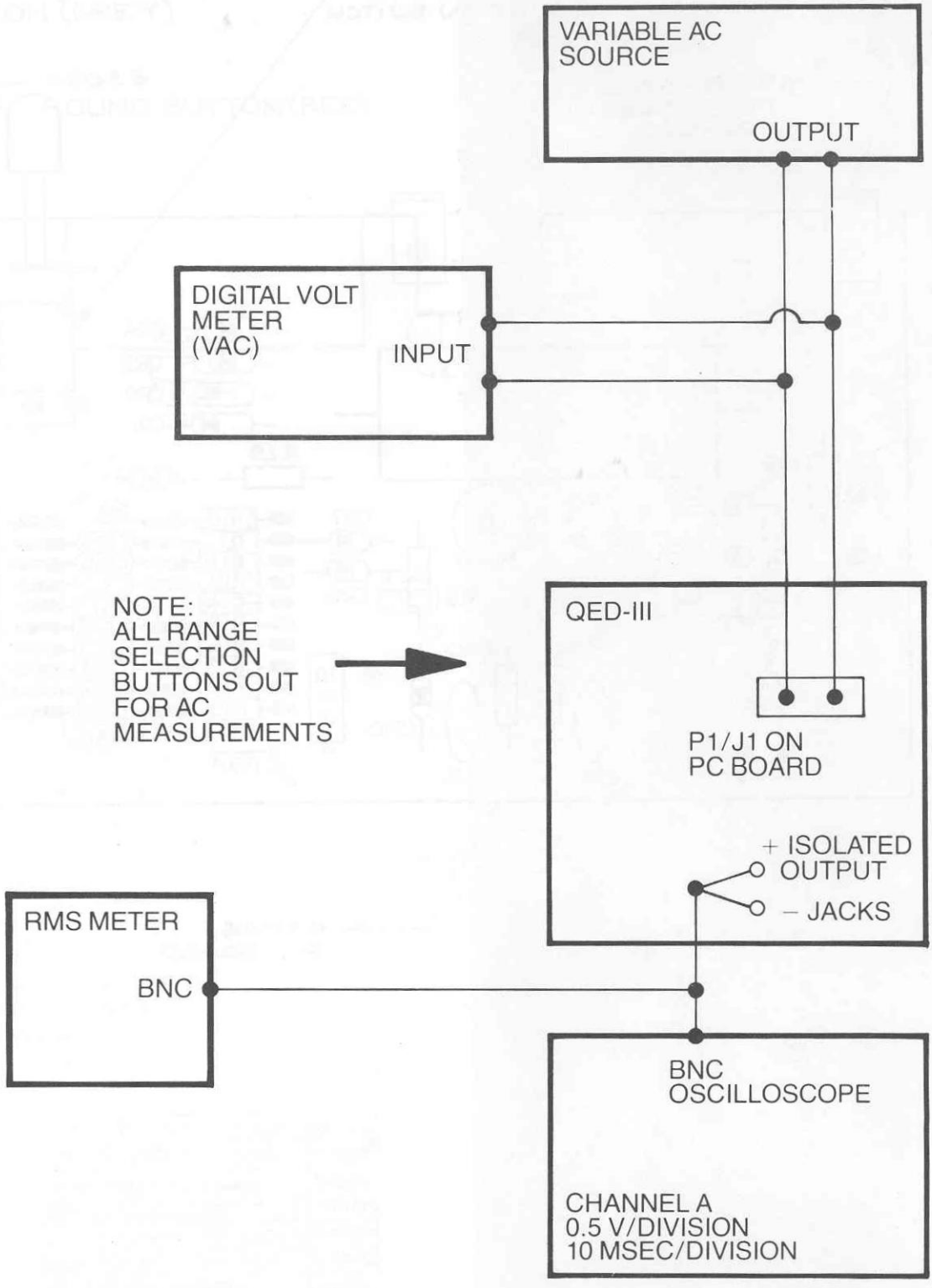


Figure 6.2.2-1. Setup for opto-isolated calibration

CALIBRATION OF OPTO-ISOLATED OUTPUT

1. Turn on the variable AC source.
2. Set the variable AC source to 99 V.
3. Depress the lefthand contact plate on the QED-III.
4. Observe the isolated output waveform on the oscilloscope.
5. Adjust R40 to eliminate any clipping of the AC signal.
6. Perform the following steps to calibrate the gain by adjusting R41:

    1. Depress the lefthand contact plate of the QED-III.
    2. Apply 99 VAC.
    3. Monitor the rms meter.
    4. Adjust R41 to obtain the desired rms reading (refer to the following rms limits):

APPLIED VOLTAGE (VAC)*	AC_{rms} (DESIRED)	AC_{rms} LIMIT
99.00	0.495	0.470--0.520
70.00	0.357	0.336--0.371
53.00	0.265	0.251--0.278
35.35	0.177	0.168--0.186
17.67	0.088	0.084--0.093
10.60	0.053	0.050--0.055

* Apply these voltages for a maximum of 2 seconds with 2 seconds between applications.

    5. Repeat Step 4 for all designated applied voltages.

7 TROUBLESHOOTING

This section provides procedures that may help isolate problems in the QED-III. **Review Section 3.1: Electrical safety, before following any of these procedures.**

The QED-III is a precision device: Bio-Tek service personnel should perform all troubleshooting. If the user performs any troubleshooting procedures, the warranty outlined in Section 3.4 may be void.

The operator can check the batteries that power the QED-III by depressing the red battery-check button on the unit.

The following troubleshooting procedures can be performed by maintenance personnel responsible for checking the QED-III. Figure 7-1 is a guide to troubleshooting procedures for the QED-III.

PROBLEM	TEST	NOTES	SUGGESTIONS
Meter needle offsets when paddle is depressed.	Switch S2	The activation switch underneath the plate may not be making contact simultaneously on the positive and negative contact points. Check the positive and negative voltages across S2 with a dual-trace oscilloscope (see Figures 5.2-1 and 3.2.2-1).	Switch S2 may be faulty.
Meter deflection is too high or too low.	PL1 & PL2	The input load may not be functioning properly. Check the resistance across PL1 and PL2 (see Figure 5.2-1): it should be 50 ohms +/- 0.5 ohms. If the resistance has increased, the meter deflection (M1) will be low; if the resistance has decreased, the meter deflection will be high.	A load resistor (R20 through R24) may be faulty.
	Resistors R20 through R24	Check each resistor (R20 through R24) with an ohmmeter to determine if a bad resistor is causing inaccurate meter deflections.	A resistor may be faulty.
	Pin 6 of operating amp U1	Check the voltage at Pin 6 of U1 (see Figure 5.2-1) with a digital volt meter. The voltage should be zero when there is no input. If the voltage is more negative than -0.7 V, U1 is not functioning properly. (Note that the CR9 protection diode limits the voltage reaching the meter (M1) to -0.7 V.) If the meter measures a positive output, adjust R33 (described in Section 6.2.1: Energy measurement).	The operating amp may be faulty.
Meter does not hold reading after defibrillator is discharged into the QED-III.	Holding capacitor C2	Lift one lead and measure the resistance across C2 with an ohmmeter (see Figure 5.2-1). The resistance should be infinite.	The holding capacitor may be faulty.
Needle does not return to zero when contact plate is released.	Discharging component FET101	Connect dual-voltage meter leads across C2, then discharge the defibrillator into the QED-III. Keep the paddles depressed on the contact plates. If a voltage drop is observed, component FET101 may not be functioning properly.	The discharging component may be faulty.
Readings are low when defibrillator is discharged into QED-III.	Bridge diodes CR1-to-CR4	Check the bridge diodes (CR1 through CR4) with an ohmmeter. Measure the resistance of each diode for both forward and reverse BIAS. The forward BIAS should be 500-to-600 ohms; the reverse BIAS should be infinite.	The bridge diodes may be faulty.

Figure 7-1. Troubleshooting procedures

8 PARTS LIST

PART #	DESCRIPTION	REFERENCE	QUANTITY
11007	4-40 x 5/8", PH screw	S2 mounting screws	2
12004	4-40 x 1/4", PH screw	Battery & resistor clip mounting screws	14
12013	8-32 x 1/2", PH screw	Contact plate mounting screws	4
12019	SCR PAN 4-40 x 3/16" SS slot	Right angle bracket screws	2
12025	2-56 x 5/8", PH screw	4-station switch mounting screws	2
12035	6-32 x 3/4", black screw	Front panel assembly mounting screws	4
14002	2-56 brass nut	4-station switch spacer nut	2
14006	10-32 hex nut	Meter connection backing nut	2
15002	4-40 locknut	S2 mounting locknut	2
15004	8-32 locknut	Contact plate mounting locknut	4
15006	10-32 locknut	Meter connection locknut	2
19003	Rivet, pop 1/8D, 0.060—0.125 G	R22 mounting rivets	2
19007	Rivet, pop Al Head/ST SHNK	R23 & 24 mounting rivets	4
21001	Diode 1N457A	CR10	1
21003	Diode 1N4004 1 A, 200 V	CR1--4, 11, 13	6
21004	Diode 1N4148 signal	CR5--9, 12	6
23009	Op Amp 207 precision	U1	1
23026	Volt reg +5 V, 78L05A	U2, 3	2
27002	Transistor 176 FET P-CH	FET101	1
28001	Opto-isolator	OI1	1
31102	Res 1.0K ohm 5% 1/4 w	R37, 39	2
31103	Res 10.0K ohm 5% 1/4 w	R32	1
31106	Res 10.0M ohm 5% 1/4 w	R34	1
31154	Res 150.0K ohm 5% 1/4 w	R27	1
31271	Res 270.0 ohm 5% 1/4 w	R36	1
31273	Res 27.0K ohm 5% 1/4 w	R35	1
31302	Res 3.0K ohm 5% 1/4 w	R38	1
31513	Res 51.0K ohm 5% 1/4 w	R30, 31	2
32018	Res 39.20K ohm 1% 1/4 w	R15	1
32022	Res 43.20K ohm 1% 1/4 w	R16	1
32024	Res 45.30K ohm 1% 1/4 w	R11	1
32026	Res 47.50K ohm 1% 1/4 w	R12	1
32030	Res 100.00K ohm 1% 1/4 w	R10	1
32044	Res 20.00K ohm 1% 1/4 w	R18	1
32066	Res 22.10K ohm 1% 1/4 w	R17	1
32088	Res 18.20K ohm 1% 1/4 w	R50	1

PART #	DESCRIPTION	REFERENCE	QUANTITY
32096	Res 1.78K ohm 1% 1/4 w	R29	1
32104	Res 56.20K ohm 1% 1/4 w	R14	1
32109	Res 63.40K ohm 1% 1/4 w	R13	1
32145	Res 8.87K ohm 1% 1/4 w	R19	1
33027	Res 0.707 ohm 1% 10 w	R24	1
33028	Res 0.293 ohm 1% 10 w	R23	1
33029	Res 2.16 ohm 1% 25 w	R22	1
33045	Res 23.4 ohm 1% 100 w	R20, 21	2
330001	Front panel assembly		1
3330025	Zener diode, 5.1 V		1
	22017	CR14	
3330026	Zener diode		1
	22017	CR15	
	22015	CR19	
3330027	Zener diode		1
	22017	CR16	
	22001	CR21	
3330028	Zener diode		1
	22017	CR17	
	22009	CR23	
3330029	Zener diode		1
	22015	CR18	
	22025	CR25	
3330030	Zener diode		1
	22036	CR27	
3330031	Zener diode		1
	22009	CR22	
	22003	CR26	
3330032	Zener diode		1
	22025	CR24	
	22004	CR28	
3330033	Zener diode		1
	22001	CR20	
	22037	CR29	
34003	Trim pot 200 ohm, 10 T	R28	1
34006	Trim pot 50K, 10 T	R33	1
34007	Trim pot 100K, 10 T	R41	1
34008	Trim pot 5K, 10 T	R40	1
42001	Isolated output jack, red	J1	1
42002	Isolated output jack, black	J2	1
42017	Term ring #10 22-18 GA	Ground lead to BNC connector	2
42027	Ring connector #8 16-14 GA	connector	2
42039	Header 10-pin 0.156 LOK	J1/PC board	1
42050	Header 5-pin 0.156 LOK	J2/PC board	1
42071	Inds 5-S 0.156 22 GA	P1, P2	2
43044	PC board QED-III, main		1

PART #	DESCRIPTION	REFERENCE	QUANTITY
44018	Case, formica		1
44020	Contact plate, left & right	P1, P2	2
44077	Front panel overlay		1
44125	Top cover overlay		1
45022	Button, round, grey	S1	3
45023	Button, round, red	S1	1
47002	Battery, 9V	BA01 through BA04	4
47004	Battery holder		4
47005	Battery clip, 9 V	One for each battery	4
49008	Spacer, 3/8"	4-station switch spacer	2
49018	Bracket, right angle	Mounts PC board with front panel	2
49021	Socket I. C., 8-pin DIP	O101 socket	1
49028	Spacer, dog bone 0.093" H	PC board assembly	3
49048	Spring clip		2
52008	Push button switch	S2	1
52014	Switch PB 4-station, 2-pole	S1	1
62002	Relay SPST DIP REED	RY101, 102	2
82001	Cap, 4.7 uF, 10 V TANT	C1	1
83007	Cap, 0.01 uF, 50 V DISC	C3, C4	2
84011	Cap, 10 uF, 100 V FILM	C2	1
92004	Meter	M1	1
92008	Bezel & holders	Meter frame	1
93021	Serial number		1